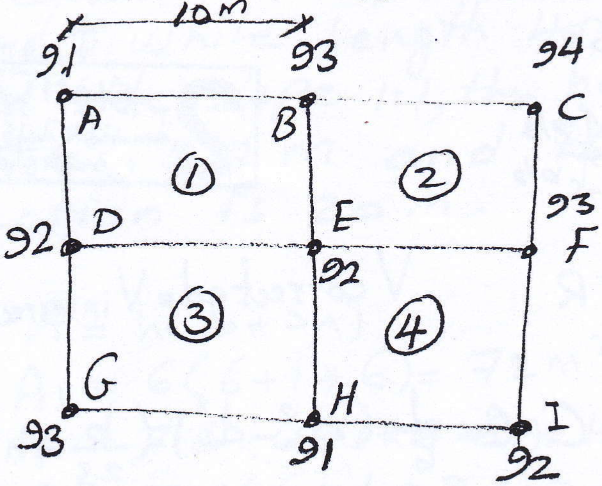
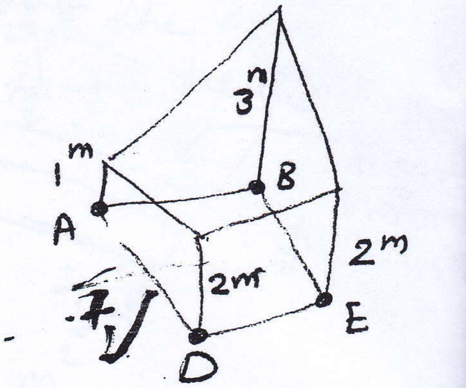
2. Volumes from spot height or spot level ⑥





excavated R.L = 90m

① – $\frac{1+3+2+2}{4} * (10 * 10) = 200 m^3$ ③ – $\frac{2+2+1+3}{4} * (10 * 10) = 200$

② – $\frac{3+4+2+3}{4} * (10 * 10) = 300 m^3$ ④ – $\frac{2+3+1+2}{4} * (10 * 10) = 200$

① + ② + ③ + ④ = $900 m^3$

OR

station	Depth of excavation (m) = h	Number of rectangles in which it occurs = n	prod (h*...
A	1	1	1
B	3	2	6
C	4	1	4
D	2	2	4
E	2	4	8
F	3	2	6
G	3	1	3
H	1	2	2
I	2	1	2
		16	36

average of height with respect to the excavated R.L = $\frac{\Sigma \text{ product}}{\Sigma \text{ number of rectangles in which it occurs}}$ = $\frac{36}{16}$ = 2.2

V = average of height with respect to the excavated R.L * Area of rectangles = 2.25 * 40

OR

$$Volume = \frac{d^2}{4}(\Sigma h_1 + 2\Sigma h_2 + 3\Sigma h_3 + 4\Sigma h_4)$$

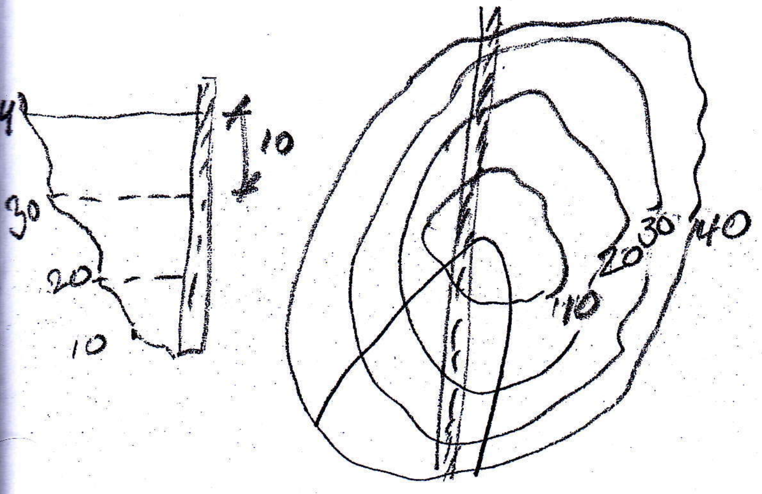
d = length of side of square

h_1 = heights used only one , h_2 = heights used twice

h_3 = height used three times , h_4 = heights used four times.

$$V_{total} = \frac{10^2}{4}((1+4+3+2) + 2(3+2+3+1) + 4(2))$$
$$= 900\, m^3$$

3. Volumes from Contour map



By end area

$$V = \frac{I}{2}[A_1 + A_n + 2(A_2 + A_3 + \dots + A_{n-1})]$$

By prismoidal

$$V = \frac{I}{3}[A_1 + A_n + 4\Sigma \text{even area} + 2\Sigma \text{odd area}]$$

I is contour interval

Example/ Calculate Volume of water between 182 to 190

Contour	190	188	186	184	182
Area(m^2)	3150	2460	1630	840	210

Sol./ 1. By end area

$$V = \frac{I}{2}[A_1 + A_n + 2(A_2 + A_3 + \dots + A_{n-1})]$$
$$= \frac{2}{2}[3150 + 210 + 2(2460 + 1630 + 840)] = 13220\, m^3$$

2. By prisomoidal

$$V = \frac{I}{3}[A_1 + A_n + 4\Sigma \text{even area} + 2\Sigma \text{odd area}]$$
$$= \frac{2}{3}[3150 + 210 + 4(2460 + 840) + 2(1630)] = 13213\, m^3$$

Example/ Using the information about the cross-sections with some missing in table shown below to calculate:

1. The area of each cross-section for cut and fill
2. Volumes of cut and fill

if the formation width increases uniformly from 9 m in fill to 12 m in cut and side slope 1:1.5.

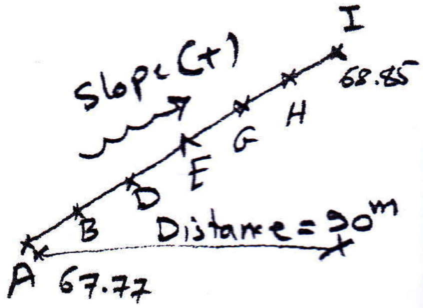
(given: Station, Surface Elev.; not given value: Grade Elev.; give: Cross-section)

Station	Surface Elev.	Grade Elev.	L	C	R
(I) 60+90	71.09	68.85	$c\,\frac{2.24}{9.36}$	$c\,\frac{2.24}{0}$	$c\,\frac{2.24}{9.36}$
(H) 60+60	70.52	68.49	$c\,\frac{2.13}{9.20}$	$c\,\frac{?}{0}$ ← 2.03	$c\,\frac{1.92}{8.88}$
(G) 60+44.4	69.53	68.30	$c\,\frac{1.44}{8.16}$	$c\,\frac{?}{0}$ ← 1.23	$\frac{0}{6.0}$
(E) 60+40.8	68.26	68.26	$c\,\frac{0.78}{7.17}$	$\frac{?}{0}$ ← 0	$f\,\frac{0.6}{5.7}$
(D) 60+37.5	67.13	68.22	$\frac{0}{4.5}$	$f\,\frac{?}{0}$ ← 1.09	$f\,\frac{1.74}{7.11}$
(B) 60+30	66.38	68.13	$f\,\frac{1.62}{6.93}$ $f\,\frac{2.07}{4.5}$	$f\,\frac{?}{0}$	$f\,\frac{2.01}{4.5}$ $f\,\frac{2.46}{8.19}$
(A) 60+00	65.36	67.77	$f\,\frac{2.16}{7.74}$ $f\,\frac{2.64}{6.0}$ $f\,\frac{2.1}{4.41}$	$f\,\frac{2.41}{0}$	$f\,\frac{2.43}{5.4}$ $f\,\frac{2.79}{7.2}$ $f\,\frac{2.8}{8.7}$

Sol.

ground or surface Elev.)$_{point}$ − grade)$_{point}$ ⟹ + Cut / − Fill

$\therefore$ grade I = 71.09 − 2.24 = 68.85^m
grade A = 65.36 + 2.41 = 67.77^m



$$slope)_{A\to I} = \frac{grade)I - grade)A}{Distance} = \frac{68.85-67.77}{90} = +0.012$$

grade)$_{next\ point}$ = grade)$_{prev.\ point}$ ± slope * distance between points

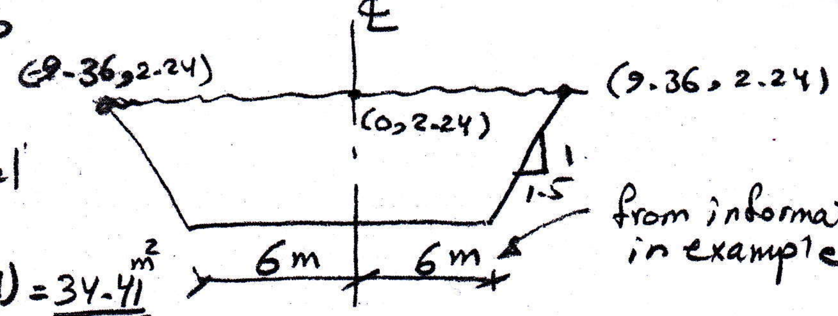
grade compute from A to I

grade)B = 67.77 + 0.012 * 30 = 68.13^m
grade)D = 68.13 + 0.012 * 7.5 = 68.22^m
grade)E = 68.22 + 0.012 * 3.3 = 68.26^m
grade)G = 68.26 + 0.012 * 3.6 = 68.30^m
grade)H = 68.30 + 0.012 * 15.6 = 68.49^m

← Filling these values in table

Now calculate the area for each cross-section

(I) @ station 60+90

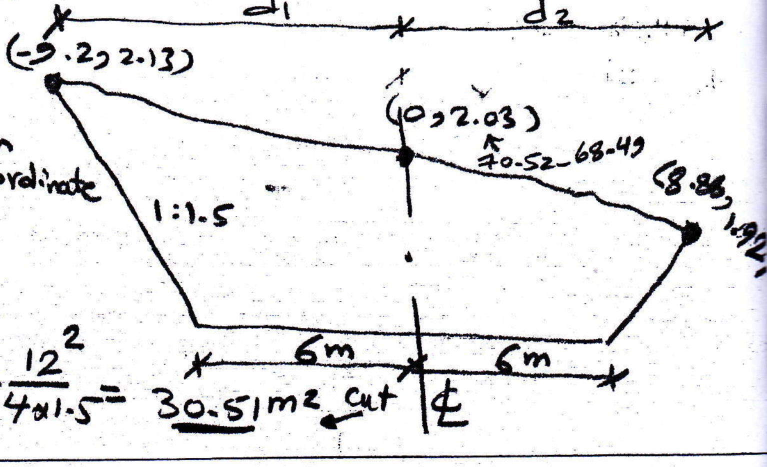


After draw the section we find this section is one-level

$\therefore A = h(b + sh)$

$= 2.24(12 + 1.5 * 2.24) = 34.41\ m^2$ cut

(H) @ station 60+60



After draw the section, we find this section is three-level

and $d_1 = 9.2^m$, $d_2 = 8.88$ ← From Coordinate

$$\therefore A = \frac{1}{2}\left(\frac{b}{2s}+h\right)(d_1+d_2) - \frac{b^2}{4s}$$

$$= \frac{1}{2}\left(\frac{12}{2*1.5}+2.03\right)(9.2+8.88) - \frac{12^2}{4*1.5} = 30.51\ m^2 \text{ cut}$$

(G) @ station 60+44.4

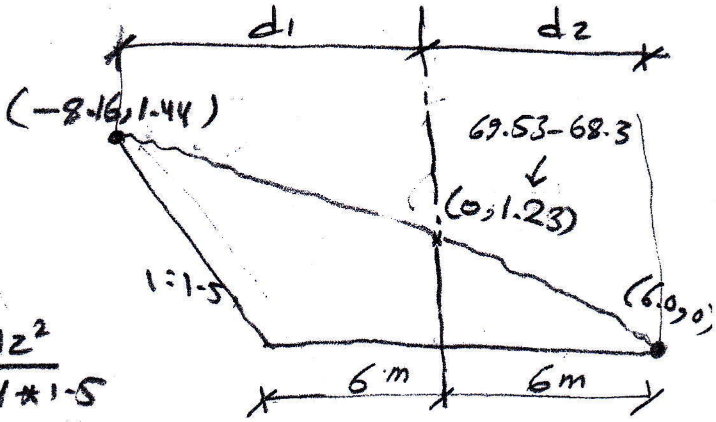
Three-level section

$d_1 = 8.16^m$, $d_2 = 6.0^m$

$$A = \frac{1}{2}\left(\frac{b}{2s} + h\right)(d_1 + d_2) - \frac{b^2}{4s}$$

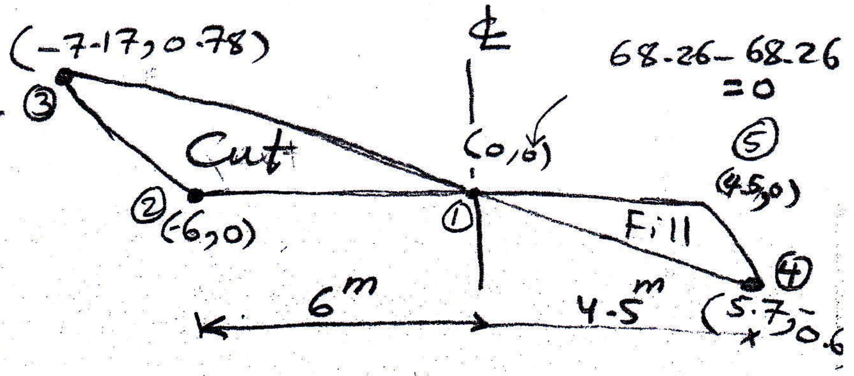
$$= \frac{1}{2}\left(\frac{12}{2*1.5} + 1.23\right)(8.16 + 6) - \frac{12^2}{4*1.5}$$

$$= 13.03\ m^2 \Leftarrow \text{cut}$$



(E) @ station 60+40.8

side hill, by coordinate to find the area of cross-section



point	x	y
1	0	0
2	-6	0
3	-7.17	0.78
1	0	0

$2A = -(-6 * 0.78) \Rightarrow A = 2.34\ m^2 \Leftarrow$ cut

point	x	y
1	0	0
4	5.7	0.6
5	4.5	0
1	0	0

$2A = (0.6 * 4.5) \Rightarrow A = 1.35\ m^2 \Leftarrow$ Fill

(D) @ station 60+37.5

$d_1 = 4.5^m$, $d_2 = 7.11^m$

$$A = \frac{1}{2}\left(\frac{b}{2s} + h\right)(d_1 + d_2) - \frac{b^2}{4s}$$

$$= \frac{1}{2}\left(\frac{9}{2*1.5} * 1.09\right)(4.5 + 7.11) - \frac{9^2}{4*1.5}$$

$$= 10.24\ m^2 \Leftarrow \text{Fill}$$